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Maine Agricultural Experiment Station

ORONO

BULLETIN 315 **DECEMBER, 1923**

ABSTRACTS OF PAPERS NOT INCLUDED IN BULLETINS, FINANCES, METEOROLOGY, INDEX.

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MAINE

AGRICULTURAL EXPERIMENT STATION

ORONO, MAINE

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BULLETIN 315

ABSTRACTS OF PAPERS PUBLISHED BY THE STATION IN 1923 BUT NOT INCLUDED IN THE BULLETINS.

A complete list of all the publications issued by and from the Station in 1923 is given on pages ix-x of the introduction to this Report. The following pages contain abstracts of the papers issued during the year that are not included in the Bulletins or Official Inspections for the year.

THE PLACE OF STOCKS IN THE PROPAGATION OF CLONAL VARIETIES OF APPLES.*

This paper is a more technical presentation of the same material that is found in Bulletin 310. The various correlation coefficients showing the relation between size and variety, kind of stock and year budded are presented in tabular form. The data presented indicate that the trees which were small when set in the orchard are relatively small at the present time, seven years after planting, and that the large trees when set in the orchard have remained relatively large and will undoubtedly be the more productive trees when the orchard reaches the bearing age. Accordingly, the best grade of nursery trees are recommended.

In this study the soil was found to be uniform and since all buds were selected from single trees for each variety the differences could not be attributed to bud variation. The only variable factor of importance is thought to be the variable root stocks on which the different trees are budded.

BUD AND ROOT SELECTION IN THE PROPAGATION OF THE APPLE.†

Experiments have been in progress at the Maine Agricultural Experiment Station for several years to determine the

*This is an abstract of a paper by Karl Sax and John W. Gowen having the same title and published in Genetics, Vol. 8, pp. 458-465, 1923.

†This is an abstract of a paper by Karl Sax having the same title and published in the Proceedings of the American Society for Horticultural Science, pp. 1-7, 1923.

effect of selecting piece roots and scions from productive and unproductive apple trees for propagation work, to determine the effect of bud selection in relation to tree growth and yield, and to determine the relation between scion or bud and the seedling stock.

In the fall of 1921 piece roots and scions were selected from four pairs of productive and unproductive Ben Davis trees about thirty years old. In case of each pair of trees the scions from the high and low yielders were grafted on their own roots. In addition the scions from the high yielder were grafted on the roots of the low yielder and vice versa, making in all four combinations of grafts for each pair of Ben Davis trees. These grafts were set in nursery rows and measurements of the nursery trees were taken at the end of the second year.

In the first and second series of reciprocal grafts the piece roots from productive trees gave much better results than the piece roots from the unproductive trees. These differences are statistically significant. In the third series the condition is reversed, as the roots from the unproductive trees gave somewhat better results than those from the productive trees. In the fourth series no significant difference was observed. Although the behavior of these piece root selections are not entirely consistent there is some indication that the roots selected from vigorous, productive trees will give somewhat better results than roots selected from unproductive types. This knowledge is of little value for commercial purposes, since the practice of taking piece roots from matured bearing trees does not seem to be entirely satisfactory from a propagative standpoint. It does, however, indicate that there are inherent differences in the root systems of apple trees. This would be expected, of course, because the root systems of the apple trees are seedlings, and no two would be alike. Some of them would be expected to give relatively good results while others would be inferior for stocks.

The scions from the productive trees gave slightly better results than scions from unproductive trees in some cases but the differences are so small, especially when compared with the differences in the selected roots, that this factor is considered of relatively little importance.

In the spring of 1922, 2000 No 1 American grown French Crab Seedlings were purchased from a wholesale nursery and set in nursery rows at Highmoor Farm. About two-thirds of

these seedlings were budded in August, 1922. Buds were selected from pairs of productive and unproductive trees growing in various commercial orchards and in our experimental orchards at Highmoor. The McIntosh and Delicious buds were selected from commercial orchards which were about twelve years old. The buds from the Ben Davis and Northern Spy were taken from our own trees on which we had complete records for the past seven or eight years. In one pair of Delicious trees and in one pair of the McIntosh trees the buds from the productive parents gave somewhat better one-year old whips than the buds from the unproductive trees. Although the differences were not large they were based on about 100 trees from each parent and the differences are probably statistically significant. Judging from the behavior of the performance of the Ben Davis buds, however, it would appear that these differences may not be due to bud mutation or inherent differences but are due simply to the difference in the condition of the parent trees. Those which are more vigorous may give somewhat better results, even when the differences in vigor are due entirely to different amounts of fertilizer received. No differences were found in the progeny of the buds from the productive and unproductive Spy trees. Since only small differences were found in the one-year old whips resulting from different parental trees it is questionable whether these differences will persist to the time when the trees reach their bearing age.

Although the French Crab Seedlings used were No. 1 grade they varied considerably in size and varied from 4 to 13 millimeters in trunk caliper. Each tree was numbered and data were taken on the seedlings and the whips. It was found that the larger seedlings gave somewhat better results than the smaller seedlings. For instance, the seedlings which had a caliper of 14 millimeters in the fall of 1922 resulted in whips 50 per cent larger than the seedlings which had a trunk caliper of only 10 millimeters in the fall of 1922. The relation between the size of the seedling and the size of the resulting whip is not, however, as large as might be expected. Moreover, there are other factors involved in the size of the one-year old whip. One of these factors is the rate of the development of the grafted bud when it starts growing in the spring. The buds which begin growth early will result in somewhat larger whips than those which are delayed in starting growth. The correlation between bud develop-

ment and the size of the resulting whip is considerably higher than the correlation between size of seedling and size of whip. These differences in rate of development of the grafted bud in the spring may be attributed to either differences in technique of budding or differences in compatibility of the grafted bud and the seedling stock.

COLOR FACTOR IN BEAN HYBRIDS.*

Some rather unusual results were obtained in certain crosses of eyed beans. The cross of the Old Fashioned Yellow Eye X Improved Yellow Eye result in "piebald" beans in the first generation which have over twice as much pigmented surface as is found in either parent. This type of eye is irregular in outline and is accompanied by circular areas of pigment on the side of the bean opposite the hilum. In the second generation the segregation is one O.F.Y.E. : two piebald : one I.Y.E., indicating that only a single pair of allelomorphic factors are involved. When these factors are in the heterozygous condition the pigmented area is more than twice as large as either parent and the eye pattern is not intermediate but is an entirely new type.

In crosses of certain eyed beans with small white beans the first generation beans were dark mottled and in the second generation segregation resulted in the ratio of 27 mottled : 9 solid : 12 eyed : 16 white. In this case the white beans apparently carried the factor for the extension of the pigment and the mottling factor. The factors for mottling can be attributed to two factors both of which are necessary for the expression of the character. If these two factors are contributed by one parent the regular 3:1 ratio of mottled to self-colored will result, but if one mottling factor is contributed by one parent and one by the other parent the segregation will be 1:1 in F_2. These mottling factors are very closely linked.

*This is an abstract of a paper by Karl Sax and Hugh C. McPhee having the same title and published in the Journal of Heredity, Vol. 14, pp. 205-208, 1923.

THE ASSOCIATION OF SIZE DIFFERENCES WITH SEED-COAT PATTERN AND PIGMENTATION IN PHASEOLUS VULGARIS.*

The study of the inheritance of size differences has been difficult because usually a large number of factors are involved which cannot be distinguished in their effects and the effects of single factor differences cannot be studied. If, however, certain factors for size differences can be found linked in the same chromosome with factors for simple qualitative differences then the size factors could be readily studied through their linkage relations. This was found to be possible in the analysis of certain bean hybrids.

Crosses between certain Eyed and White beans resulted in completely pigmented mottled beans in F_1 and mottled, self-colored, eyed and white beans in F_2. Mottling is dependent upon two factors in the same linkage group, both of which are necessary to produce mottling. In one of the hybrids both factors were in a single chromosome and since the factors are closely linked they behave essentially the same as a single factor in heredity. Completely pigmented beans are dependent upon either one or two extension factors, the recessive of which results in eyed beans. The pigmentation is dependent upon a single factor.

In all crosses of large pigmented beans with small white beans the pigmented F_2 segregates had a mean seed weight greater than that of the white segregate. In a cross Improved Yellow Eye X White 1228 the difference in average seed weight between the homozygous pigmented F_2 segregate and white was found to be about 1/6 of the F_2 range. The difference between the weight of the heterozygous pigmented F_2 segregate and the white segregate is only about half as great as the difference between the homozygous pigmented individual and the white. Thus a size factor or group of closely linked size factors in the 1n or heterozygous condition has only about one-half of the effect that it has in the 2n or homozygous condition. This lack of dominance is of interest in connection with the hybrid-vigor hypothesis. Factor differences for seed weight are also associated or linked with one or both of the eye factors, with eye pattern factors, and

*This is an abstract of a paper by Karl Sax having the same title and published in Genetics, Vol. 8, pp. 301-321, 1923.

with factors which determine the color of the pigment. Size differences even in case of blending inheritance where several factors are involved, may be affected by the independent action of the size factors in the different linkage groups. These factors, when combined, have a cumulative effect.

PERMANENCE OF TREE PERFORMANCE IN A CLONAL VARIETY, AND A CRITIQUE OF THE THEORY OF BUD MUTATION.*

There is great variability in productivity of individuals within clonal varieties of apple and citrus trees. The average coefficient of variation for yield was found to be 70 for Ben Davis apple trees in Maine, 28 for Rome trees in New York, 41 for Jonathan apple trees in Utah, and from 36 to 54 in certain citrus varieties in California. The differences in performance of individual trees were relatively permanent, as indicated by the high value of the interannual correlations which varied from .51 for Rome apple trees to .74 for selected Washington Navel orange trees.

Our problem is to determine what part of the consistent differences in productivity are due to environmental conditions and to what extent these differences are due to inherent differences in individual trees. The important known factors which may cause variability in trees of a clonal variety are: (1) soil heterogeneity, including the effects of soil moisture, elevation, and exposure; (2) differences in vigor and compatibility of seedling stocks on which the trees are grafted; and (3) inherent differences in scions or buds of a clonal variety due to bud mutation.

Soil heterogeneity was found to cause considerable variability in yield of trees. A soil heterogeneity of .40 in our Ben Davis orchard was reduced to —.07 by selecting a uniform block of 95 trees and as a result the coefficient of variability was reduced from 58 to 43 in 1914. A reduction in soil heterogeneity also reduced the variability of Navel and Valencia orange trees in California. The variability of soil is also shown by a coefficient of variability of 47 for 72 blocks of 16 trees each in our

*This is an abstract of a paper by Karl Sax and John W. Gowen having the same title and published in Genetics, Vol. 8: pp. 179-211, 1923.

Ben Davis orchard and the relative permanence of these differences is indicated by an average interannual correlation of .47. Consistent differences in tree performance have apparently been considered by some investigators as proof of inherent differences in trees of a clonal variety, but the fact that permanent differences in yield have been found in plots of apple trees, and permanent plots of millet, alfalfa and maize, should discredit any such idea.

On the other hand, much variability in tree performance may exist even on soil that is, in general, homogeneous. On soil that was found to be uniform when tested for soil heterogeneity the coefficient of variation was found to be 43 for Ben Davis apple trees, 35 for Jonathan apple trees in Utah, 26 for Rome apple trees in New York, 48 for seedling walnuts, and 28 for Navel oranges in California. Of even greater importance is the fact that these differences in productivity are just as permanent as the greater differences found on highly heterogeneous soil. For example the interannual correlation was found to be 56 for 882 Ben Davis trees on heterogeneous soil ($r = .40$), while for 95 trees on uniform soil ($r = -.07$), the interannual correlation was .65. In other words soil heterogeneity has no effect on the permanence of permanent differences in yield. This may sound like a paradoxical statement, but a little consideration will show its validity. If, for instance, all the trees in our Ben Davis orchard were placed in absolutely uniform soil the permanence of differences in tree productivity would be just as great as before although the variability of total yield would be reduced. It is impossible to perform such an experiment, but it is possible to eliminate the effect of soil differences by holding the factor of soil variability constant. This was done, and yet there was no reduction in the permanence of differences in yield.

Since variability in tree productivity may exist on uniform soil and since soil differences had no effect on the permanence of differences in yield of trees, other factors must be responsible for the permanence of variability in clonal varieties of fruit trees. One of these factors is the variability of seedling stocks on which the clonal varieties are grafted. Seedling stocks are known to be extremely variable and to cause variability in growth of scions or buds. In our seedling orchard, 586 trees which were planted in 1911, vary in circumference from two to eighteen centimeters and the coefficient of variability was found to be 32 per cent.

In our "stock and scion" orchard we find a high correlation between the size of the tree shortly after it was set in the orchard and its size six years later. All buds of each variety were from a single tree, thus eliminating any possible effect of bud mutation. Thus the consistent differences in size can often be attributed to variable stocks. Webber has shown the effect of variable stocks on growth of citrus trees in California. Although the work on stocks is limited, there is sufficient evidence to show that their variability is an important factor in causing differences in yield of trees of a clonal variety.

Variability in productivity of trees of a clonal variety have also been attributed to bud variation. The paucity of bud mutations affecting qualitative characters in the apple, and the bud selection work of Whitten, Cummings, and Rawes, does not support the belief that bud mutation is an important factor in causing variation in performance of apple trees. The bud-selection work of Macoun recently reported by Davis does, however, show the transmission of high and low productivity to the progeny of budding. Whether these differences in productivity are due to bud mutation or to the transmission of disease may well be questioned. Davis believes that buds from a relatively unproductive but vigorous healthy tree, would give progeny as productive as buds selected from productive vigorous trees. At any rate the evidence that buds should be selected only from vigorous trees does not necessarily mean that bud mutation is a factor in causing variability within a clonal variety.

As the result of the work of Shamel and his co-workers bud variations influencing productivity have been generally considered to be of common occurrence in citrus varieties. Although these writers do not directly state in the papers cited, that buds from productive trees result in productive progeny and that buds from unproductive trees produce unproductive progeny, they do state that "all of the strains described can be isolated through bud selection" and in most cases the "strains" are described as "heavy bearers," "less productive," or "unproductive," as compared with the original or standard strain of the variety. Shamel and his colleagues may have evidence to prove that in some cases differences in productivity are due to bud mutation, but there are no data in any of their publications to date to warrant such a conclusion.

In conclusion we wish to emphasize the relative part played by environmental fluctuating factors and factors which control the permanence in yield of trees of a clonal variety. The variation remaining after the control of any factor is equal to $\sigma_x\sqrt{1-r^2}$. In other words the percentage of variation in yield remaining is equal to $\sqrt{1-r^2}$. The percentage of variation remaining for the permanence in variability is, for the obviously highly selected data on the Washington Navel orange, $\sqrt{1-.74^2}$ or 67 per cent, for the Valencia orange 86 per cent, for the Lisbon lemon 78 per cent, for the Rome apple trees 86 per cent and for the Ben Davis apple trees 85 per cent. Thus, excluding the Washington Navel orange data as being at least of doubtful value, only from 14 to 22 per cent of the variability in yield is due to factors causing permanence in yield. Variable stocks and inherent differences in scions are the important known factors which may cause such permanent differences in yield, and if differences in stocks cause much of this remaining variability, certainly other factors, such as bud mutation, can play little part in causing permanent differences in yield of trees of a clonal variety.

The relative effect of various factors in causing variability in yield of trees has been determined for our Ben Davis orchard. About 62 per cent of the variability is due to environmental factors other than soil. Soil heterogeneity causes 18 per cent of the variability. Only about 15 per cent of the tree variability can be attributed to factors which cause permanence of yield, i.e., grafting stocks, bud mutation, and unknown factors.

THE RELATION BETWEEN CHROMOSOME NUMBER, MORPHOLOGICAL CHARACTERS AND RUST RESISTANCE IN SEGRAGATES OF PARTIALLY STERILE WHEAT HYBRIDS.*

The common bread wheats have frequently been crossed with members of the Emmer group, to combine the bread making qualities of the common wheat with the disease resistance and drouth resistant qualities of the Emmer wheat. These results have in no case given commercial varieties combining the desirable characters of the two parents although hundreds of thousands of segregates have been grown.

*This is an abstract of a paper by Karl Sax having the same title and published in Genetics, Vol. 8, pp. 301-321, 1923.

A cytological examination of these two wheat groups showed that the Emmer group has 14 haploid chromosomes while the Vulgare group or common wheat has 21 haploid chromosomes. Crosses between members of these two groups result in partially sterile hybrids. In the reduction division of the F_1 plant there are 14 double chromosomes and 7 single chromosomes. The single chromosomes pass at random to one pole or the other without dividing so that the gametes of the F_1 plant contain from 14 to 21 chromosomes.

A cytological examination of 46 F_3 segregates of a cross of *Triticum vulgare* X *T. durum* shows that most of the segregates have either 14 or 21 chromosomes, or an intermediate number which could result from the union of a 14 chromosome gamete with a 21 chromosome gamete. Apparently the segregates with an intermediate number of chromosomes tend to be eliminated due to sterility and that the ultimate homozygous fertile segregates will have either 14 or 21 chromosomes.

It was also found that the segregates which had 14 chromosomes had a morphological and physiological characters of the Emmer parent while the 21 chromosome segregates resembled the Vulgare parent in appearance and disease resistance. These results would indicate that the 7 additional chromosomes of the Vulgare wheat determine to a considerable extent the distinguishing characters of the common wheat due to a reduplication of hereditary factors or to specific factors in these extra 7 chromosomes.

The cytological and genetic data would indicate that many of the desirable characteristic properties of the Emmer and Vulgare wheat cannot be combined in a homozygous condition. This conclusion is supported by breeding experiments in all parts of the world. It may be possible, however, by selecting the most fertile combinations of species crosses to occasionally combine certain of the desirable characteristics of the different species.

There is a rather striking relation between chromosome number and economic value of the various wheat. With an increase in the chromosome number from 7 to 21 there is an increase in variability and adaptabliity, increased susceptibility to various diseases and a better quality of gluten in the grain.

It is concluded that the breeding of wheat varieties to combine disease resistance with high yield and quality of grain is much more likely to be successful if the parents are selected within the Vulgare group.

PRODUCTIVE AND UNPRODUCTIVE TYPES OF APPLE TREES.*

In an orchard of 881 Ben Davis trees it was found that there were a large number of types of trees in respect to shape and size. The various trees were classed into six different types. There was found to be a high relation between tree type and yield. The unproductive types were upright, small and slender, while the productive types of trees were found to be large and spreading. Tree type was also closely associated with trunk girth and for practical purposes trunk girth would probably be a better index of productivity than type of tree, due to the elimination of the personal judgment of the observer.

The different types of trees which are associated with difference in productivity were found to be due to a considerable extent to soil heterogeneity. There is also considerable evidence that variable root stocks are responsible for some of the variability in type and yield. Bud mutation is considered a minor factor in causing the variability of yield in trees of a clonal variety.

A "SPINDLING-TUBER DISEASE" OF IRISH POTATOES.†

This paper briefly describes the effects, and proofs of infectiousness, of a degeneration disease commonly known as "running-long" or "running-out."

MUTATIONS OF THE POTATO. TWO SOMEWHAT UNSTABLE LEAF-FORM SPORTS OF THE IRISH POTATO.‡

This paper describes two types of somatic mutations that were unstable enough to revert in part to the varietal norm. One

*This is an abstract of a paper by Karl Sax and John W. Gowen having the same title and published in the Journal of Heredity, Vol. 12, pp. 291-300, 1921.

†This is an abstract of a paper by Eugene S. Schultz and Donald Folsom having the same title and published in Science n. s. Vol. 57, No. 1466, p. 149. February 2, 1923.

‡This is an abstract of a paper by Donald Folsom having the same title and published in the Journal of Heredity, Vol. 14, No. 1, pp. 45-48. April, 1923.

type is characterized by simple leaves and the other by distorted, thick or fleshy, glabrous leaves.

TRANSMISSION, VARIATION, AND CONTROL OF CERTAIN DEGENERATION DISEASES OF IRISH POTATOES.*

The summary in this paper may best serve as an abstract, and is as follows:

(1) Degeneration diseases of potatoes, in the absence of known identifying causes, are symptom complexes whose elementary unit symptoms can and should be determined in the same standard variety or varieties and in the same environment.

(2) Research with these diseases is developing a somewhat distinct technic and terminology.

(3) In the Green Mountain variety, several degeneration diseases have been distinguished and transmitted—namely, mild mosaic, leaf-rolling mosaic, rugose mosaic, streak, leaf roll, spindling-tuber disease, and unmottled curly dwarf.

(4) In Green Mountains, mild mosaic was not transmitted by contact except in stem and tuber grafts.

(5) A leaf-mutilation method of inoculation has certain advantages over other methods. In Green Mountains this method transmitted mild mosaic, with the effectiveness increased by insect-cage or greenhouse conditions as compared to open-field conditions, by inclosure within a damp chamber, and by repetition.

(6) In Green Mountains aphids *(Macrosiphum solanifolii* Ashmead) transmitted mild mosaic, both alone and in combination with leaf roll and with spindling tuber, while negative results were secured with flea beetles *(Epitrix cucumeris* Harris) and Colorado potato beetles *(Leptinotarsa decemlineata* Say.).

(7) In Green Mountains, aphids from plants with a "curly-dwarf" combination apparently consisting of leaf-rolling mosaic and spindling tuber together, transmitted the curly-dwarf combination to part of a hill and spindling tuber alone to the other part, distinction being made between different tuber units of the second generation.

*This is an abstract of a paper by E. S. Schultz and Donald Folsom having the same title and published in Journal of Agricultural Research, Vol. 25, No. 2, pp. 43-117. July 14, 1923.

(8) Leaf-mutilation inoculation transmitted both rugose mosaic and streak readily in Green Mountains.

(9) Leaf roll was transmitted neither by contact except in grafts, nor by leaf-mutilation inoculation.

(10) Spindling-tuber disease is characterized, and proofs given of its being a degeneration disease, spreading in the field, being perpetuated by the tubers (shown in part by mechanical measurements), and being transmitted by tuber grafts, stem grafts, leaf mutilation, and aphids.

(11) Unmottled curly dwarf was transmitted by leaf-mutilation inoculation and by aphids.

(12) Combinations of symptoms exist that include more than one degeneration disease in the same plant. Aphids sometimes transmit only one disease from such a plant, but more often transmit the combination.

(13) In Irish Cobblers, leaf roll was transmitted by grafting and by aphids but not by leaf-mutilation inoculation, which is successful with all other degeneration diseases tested.

(14) In New White Hebrons in 1921, leaf-roll and net-necrosis percentages increased with the average weight of the tubers.

(15) Leaf-mutilation inoculation of Green Mountains in 1920 effected intervarietal transmission of rugose mosaic, a combination of leaf-rolling mosaic and spindling tuber, and unmottled curly dwarf, but was ineffective with mild mosaic and leaf roll. Comparison inoculations with aphids with four of the sources of inoculum gave similar results, transmitting rugose mosaic to Green Mountains from curly-dwarf plants in the Rural group.

(16) Leaf-mutilation inoculation of Green Mountains in 1921 effected intervarietal transmission of streak, rugose mosaic and streak together, rugose mosaic, leaf-rolling mosaic, and mild mosaic in insect cages (uncontrolled in the open field), but not leaf roll. With spindling tuber (uncontrolled in the open field) present in the progeny, leaf-rolling mosaic having been transmitted formed a curly-dwarf combination. Rugose mosaic was thus transmitted from Carman No. 3 (Rural group) to Rural New Yorker, and from this and two seedling varieties to both Green Mountains and Irish Cobblers, but the symptom complexes were not identical in any two varieties.

(17) Streak did not appear the same before and after tuber perpetuation.

(18) Comparison inoculations with juice in capillary glass tubes were much less effective than leaf mutilation, with rugose mosaic and streak.

(19) Aphid inoculations of Green Mountains in 1921 effected intervarietal transmission of leaf-rolling mosaic from curly-dwarf plants in three varieties of the Rural group, of unmottled curly dwarf and spindling tuber (separately) from Irish Cobblers, of rugose mosaic from one seedling variety, and of leaf-rolling mosaic and rugose mosaic together from two seedling varieties. Aphids also transmitted rugose mosaic to Irish Cobblers from two seedling varieties.

(20) Leaf-mutilation inoculations of Green Mountains in 1922 resulted in current-season symptoms of streak, rugose mosaic and streak combined, and rugose mosaic with and without streaking. Comparison inoculations with mild mosaic, leaf roll, and spindling tuber gave no current-season symptoms in the open field. Comparison inoculations under insect cages gave current-season symptoms with mild mosaic and spindling tuber. Several different symptom complexes yielded only rugose mosaic as the current-season effect of inoculation, sometimes with rugose mosaic somewhat masked in the original complex. Results with Green Mountains were somewhat duplicated in Irish Cobblers and Bliss Triumphs, but some varietal modification of symptoms apparently occurred in these and seedling varieties.

(21) In greenhouse inoculations, transmission of mild mosaic from Bliss Triumphs to Green Mountains was effected to some extent with juice in capillary glass tubes, but not with immersion of a split stem in diseased juice. It was effected more readily with leaf mutilation as the number of inoculated leaves was increased, and more readily with aphids as the number of individual insects was increased, being possible with one individual aphid.

(22) In greenhouse leaf-mutilation inoculations, rugose mosaic was transmitted from a seedling variety to Green Mountains and from Green Mountains to Irish Cobblers, but leaf roll was not transmitted from Irish Cobblers to Green Mountains.

(23) Interspecific inoculations with leaf mutilation and aphids indicate that tobacco mosaic is not identical with potato mild mosaic, that tomato is susceptible to both of these mosaics and also to potato rugose mosaic, and that nightshade *(Solanum*

nigrum L.) is susceptible to potato mild mosaic. Raspberry mosaic seems harmless to potatoes.

(24) The various degeneration diseases of potatoes are different as to their economic importance resulting from their distribution and effect upon yield rate and quality.

(25) Natural transmission by insects contributes to the difficulty of the control problem.

(26) Perpetuation occurs in tubers and not in soil alone.

(27) About 10 days were required for the mild mosaic virus to diffuse from inoculated leaves to the tubers.

(28) Mosaic plants from the same seed tubers sometimes show different symptom complexes in different environments. Mottling is suppressed by southern regions and by higher temperatures. Dwarfing of the tubers, and therefore reduction of yield rate, was more pronounced in a southern region.

(29) Shading tended to increase mosaic mottling and decrease leafrolling.

(30) In duplicate plots leaf roll and mosaic were contracted by healthy lots growing between rows of diseased lots, more in some regions than others.

(31) Selection of tubers without knowledge of the parent plants can not eliminate seed from diseased plants infected late the preceding season.

(32) The digging of selected healthy hills progressively later in the growing season was correlated with greater numbers of aphids and with greater amounts of disease in the progeny.

(33) Hill selection in fields containing diseased plants throughout the growing season is disappointing as a means of eliminating disease, but sometimes gives better results than using unselected stock from the same field.

(34) Proximity and a heavy aphid infestation increased the spread of mild mosaic, while sufficient isolation from diseased stocks reduced it so that a state of freedom from the disease was maintained. Isolation by 30 meters* was insufficient, and over 400 meters was sufficient.

(35) Conditions that reduced aphid dispersal from diseased to healthy hills also reduced the amount of disease transmission.

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*A meter is about a yard, and 5 meters equal approximately one rod.

(36) Potato degeneration is largely, and possibly is entirely, a result of the increase of, and injury by, certain degeneration diseases.

(37) The potato degeneration-disease problem is on the whole similar for all potato-growing regions, but is complex enough to vary somewhat from one region to another.

METEOROLOGICAL OBSERVATIONS.

For many years the meteorological apparatus was located in the Experiment Station building and the observations were made by members of the Station Staff. June 1, 1911, the meteorological apparatus was removed to Wingate Hall and the observations are in charge of Dr. James S. Stevens, professor of physics in the University of Maine.

In September, 1914, the meteorological apparatus was moved to Aubert Hall, the present headquarters of the physics department.

The instruments used are at Lat. 44° 54′ 2″ N., Lon. 64° 40′ 5″ W. Elevation 135 feet.

The instruments used are the same as those used in preceding years, and include: Maximum and minimum thermometers; rain guage; self-recording anemometer; vane; and barometers. The observations at Orono now form an almost unbroken record of fifty-five years.

Meteorological Summary for 1923.

1923	January	February	March	April	May	June	July	August	September	October	November	December	Average	Total
Highest temperature	46	32	62	71	79	91	88	86	79	70	59	53	—	—
Lowest temperature	–26	–21	–12	4	33	39	43	35	30	21	14	4	—	—
Mean temperature	11.72	9.36	19.7	36.05	48.89	59.05	62.43	58.64	55.89	46.72	36.15	29.31	34.495	—
Mean temperature in 55 years	15.92	14.87	30.09	39.55	51.28	59.37	65.98	65.78	59.44	50.40	37.58	23.35	42.808	—
Total precipitation in inches	3.88	1.619	3.42	6.98	1.87	2.86	3.86	1.65	2.15	2.92	3.16	3.73	—	35.119
Mean total precipitation in 55 years	2.59	3.41	3.91	3.01	3.38	3.43	3.44	2.34	3.34	3.72	3.39	3.35	—	39.31
Number of days with .01 precipitation or more	10	5	9	11	8	10	7	6	8	10	9	9	—	102
Snowfall in inches	42.5	20	31	4	—	—	—	—	—	—	—	19.5	—	117
Mean snowfall in 55 years	21.68	22.01	14.75	5.69	.211	—	—	—	—	.699	6.96	16.53	—	—
Number of clear days	12	16	12	9	10	8	8	9	9	9	12	7	—	121
Number of fair days	6	6	7	11	14	14	12	15	14	11	5	3	—	118
Number of cloudy days	13	6	12	10	7	8	11	7	6	11	13	21	—	125
Average velocity of wind per hour in miles	6.569	4.527	6.283	7.77	6.056	4.394	3.863	4.613	3.941	4.491	4.149	4.643	5.108	—

REPORT OF THE TREASURER.

The Station is a department of the University and its accounts are kept in the office of the Treasurer of the University. The books, voucher files, etc., are, however, all distinct from those of the other departments of the University. The classification of accounts is that prescribed by the auditors on the part of the Federal Government, and approved by the State Auditor. All of the accounts are audited by the State Auditor, and the Hatch Fund and Adams Fund accounts are also audited by the Office of Experiment Stations acting for the United States Secretary of Agriculture in accordance with Federal Law.

The income of the Station from public sources for the year that ended June 30, 1923, was:

U.S. Government, Hatch Fund appropriation	$15,000.00
U.S. Government, Adams Fund appropriation	15,000.00
State of Maine, Animal Husbandry investigation appropriation	5,000.00
State of Maine, Aroostook Farm investigation	5,000.00
State of Maine, Highmoor Farm investigations	5,000.00

The cost of maintaining the laboratories for the inspection analyses is borne by analysis fees and by the State Department of Agriculture. The income from sales at the experiment farms and poultry plant is used for the expense of investigations. The printing is paid for by an appropriation to the University.

At Aroostook Farm there are in connection with the cooperative work with the Federal Department of Agricultue expenditures mostly under "labor" for the Department and for which the Station is reimbursed. There are also certain expenditures for the Department made from sales of crops from Department investigations that do not appear in the tabular statements. They are carried as distinct and separate accounts, always with credit balances, on the Station ledger.

REPORT OF THE TREASURER FOR YEAR ENDING JUNE 30, 1923.

DISBURSEMENTS.

	Hatch Fund	Adams Fund	Animal Husbandry Investigations
Salaries	$6402.51	$14716.56	--------
Labor	3520.68	--------	2988.96
Publications	90.94	--------	--------
Postage and Stationery	400.80	52.00	152.00
Freight and Express	267.69	2.14	190.36
Heat, light, water and power	853.54	--------	421.31
Chemical and laboratory supplies	6.54	--------	--------
Seeds, plants and sundry supplies	496.76	69.73	488.50
Fertilizers	179.46	--------	304.39
Feeding stuffs	1467.35	--------	1127.52
Library	565.09	--------	--------
Tools, machinery and appliances	16.47	--------	68.54
Furniture and fixtures	120.77	--------	12.10
Scientific apparatus and specimens	10.67	--------	--------
Live stock	--------	--------	--------
Traveling expenses	406.77	159.57	39.59
Contingent expenses	--------	--------	329.34
Buildings and land	193.96	--------	38.68
Total	$15000.00	$15000.00	$6161.29*

*$1161.29 from sales funds.

REPORT OF THE TREASURER FOR YEAR ENDING JUNE 30, 1923.

DISBURSEMENTS.

	Aroostook Farm	Highmoor Farm	General Account	Inspection Analysis
Salaries	$1116.66	$1700.04	--------	$10961.71
Labor	4129.35	2191.02	314.83	--------
Publications	--------	--------	4.15	--------
Postage and Stationery	23.75	80.45	15.50	53.12
Freight and express	82.73	159.20	9.03	103.09
Heat, light, water and power	138.75	327.97	45.26	451.66
Chemical and laboratory supplies	--------	--------	--------	259.18
Seeds, plants and sundry supplies	582.91	609.01	240.25	30.00
Fertilizers	1033.45	--------	211.75	--------
Feeding stuffs	245.48	409.98	351.50	--------
Library	--------	--------	105.18	8.00
Tools, machinery and appliances	1018.09	754.90	43.54	--------
Furniture and fixtures	17.25	84.46	1.60	--------
Scientific apparatus and specimens	--------	--------	19.96	15.20
Live stock	--------	--------	--------	--------
Traveling expenses	89.80	60.79	219.33	--------
Contingent expenses	80.80	15.79	54.02	10.00
Buildings and land	76.57	74.64	9.66	--------
Total	$8635.59*	$6468.25†	$1645.59	$11891.96

*$3635.59 from sales funds.
†$1468.25 from sales funds.

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THIRTY-NINTH ANNUAL REPORT

OF THE

Maine Agricultural Experiment Station

ORONO, MAINE

1923

UNIVERSITY OF MAINE

1923

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

ORGANIZATION JANUARY TO JUNE, 1923

THE STATION COUNCIL

PRESIDENT CLARENCE C. LITTLE,	*President*
DIRECTOR WARNER J. MORSE,	*Secretary*
ORA GILPATRICK, Houlton, THOMAS E. HOUGHTON, Fort Fairfield, FRANK E. GUERNSEY, Dover,	*Committee of Board of Trustees*
FRANK P. WASHBURN, Augusta,	*Commissioner of Agriculture*
EUGENE H. LIBBY, Auburn,	*State Grange*
WILSON H. CONANT, Buckfield,	*State Pomological Society*
JOHN W. LELAND, Dover,	*State Dairymen's Association*
LEONARD C. HOLSTON, Cornish,	*Maine Livestock Breeders' Ass'n.*
WILLIAM G. HUNTON, Portland,	*Maine Seed Improvement Ass'n.*

AND THE HEADS AND ASSOCIATES OF STATION DEPARTMENTS, AND THE DEAN OF THE COLLEGE OF AGRICULTURE

THE STATION STAFF

ADMINISTRATION	WARNER J. MORSE, PH. D.,	*Director*
	MARY L. NORTON,	*Clerk*
	CHARLES C. INMAN,	*Clerk*
	ILA K. WHITE,	*Clerk*
BIOLOGY	JOHN W. GOWEN, PH. D.,	*Biologist*
	KARL SAX, SC. D.,	*Biologist*
	MARJORIE GOOCH, B. S.,	*Assistant*
	MILDRED R. COVELL,	*Clerk*
	EMMELINE D. WILSON,	*Laboratory Assistant*
CHEMISTRY	JAMES M. BARTLETT, M. S.,	*Chemist*
	ELMER R. TOBEY, CH. E.,	*Associate*
	C. HARRY WHITE, PH. C.,	*Assistant*
ENTOMOLOGY	EDITH M. PATCH, PH. D.,	*Entomologist*
	ALICE W. AVERILL,	*Laboratory Assistant*
PLANT PATHOLOGY	WARNER J. MORSE, PH. D.,	*Pathologist*
	DONALD FOLSOM, PH. D.,	*Associate*
	VIOLA L. MORRIS,	*Laboratory Assistant*
AROOSTOOK FARM	....	*Associate Biologist*
	PERLEY H. DOWNING,	*Superintendent*
HIGHMOOR FARM	WELLINGTON SINCLAIR,	*Superintendent*
	....	*Scientific Aid*

MAINE

AGRICULTURAL EXPERIMENT STATION

ORONO, MAINE

ORGANIZATION JULY TO DECEMBER, 1923

THE STATION COUNCIL

PRESIDENT CLARENCE C. LITTLE,	*President*
DIRECTOR WARNER J. MORSE,	*Secretary*
ORA GILPATRICK, Houlton, THOMAS E. HOUGHTON, Fort Fairfield, FRANK E. GUERNSEY, Dover,	*Committee of Board of Trustees*
FRANK P. WASHBURN, Augusta,	*Commissioner of Agriculture*
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WILSON H. CONANT, Buckfield,	*State Pomological Society*
JOHN W. LELAND, Dover,	*State Dairymen's Association*
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ADMINISTRATION	WARNER J. MORSE, PH. D.,	*Director*
	CHARLES C. INMAN,	*Clerk*
	MARY L. NORTON,	*Clerk*
	MARGARET M. HONEY,	*Clerk*
BIOLOGY	JOHN W. GOWEN, PH. D.,	*Biologist*
	KARL SAX, SC. D.,	*Biologist*
	MARJORIE GOOCH, M. S.,	*Assistant*
	MILDRED R. COVELL,	*Clerk*
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	ALICE W. AVERILL,	*Laboratory Assistant*
PLANT PATHOLOGY	DONALD FOLSOM, PH. D.,	*Pathologist*
	LOUISE M. BAKER,	*Laboratory Assistant*
AROOSTOOK FARM	HUGH B. SMITH,	*Assistant Biologist*
	PERLEY H. DOWNING,	*Superintendent*
HIGHMOOR FARM	IVA A. MERCHANT, B.S.,	*Scientific Aid*
	WELLINGTON SINCLAIR,	*Superintendent*

The publications of this Station will be sent free to any address in Maine. All requests should be sent to

Agricultural Experiment Station,

Orono, Maine.

CONTENTS

ANNOUNCEMENTS

Establishment of the Station

The Maine Fertilizer Control and Agricultural Experiment Station, established by Act of the Legislature approved March 3, 1885, began its work in April of that year in quarters furnished by the College. After the Station had existed for two years, Congress passed what is known as the Hatch Act, establishing agricultural experiment stations in every state. This grant was accepted by the Maine Legislature by an Act approved March 16, 1887, which established the Maine Agricultural Experiment Station as a department of the University. The reorganization was effected in June, 1887, but work was not begun until February 16, 1888. In 1906, Congress passed the Adams Act for the further endowment of the stations established under the Hatch Act.

The purpose of the experiment stations is defined in the Act of Congress establishing them as follows:

"It shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantage of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manure, natural and artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states or territories."

The work that the Experiment Station can undertake from the Adams Act fund is more restricted and can "be applied only to paying the necessary expenses for conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective states and territories."

INVESTIGATIONS.

The Station continues to restrict its work to a few important lines, believing that it is better for the agriculture of the State to study thoroughly a few problems than to spread over the whole field of agricultural science. It has continued to improve its facilities and segregate its work in such a way as to make it an effective agency for research in agriculture. Prominent among the lines of investigation are studies upon the food of man and animals, the diseases of plants and animals, breeding of plants and animals, orchard and field experiments, poultry investigations, and entomological research.

INSPECTIONS.

Up to the close of the year 1913, it had been the duty of the Director of the Station to execute the laws regulating the sale of agricultural seeds, apples, commercial feeding stuffs, commercial fertilizers, drugs, foods, fungicides and insecticides, and the testing of the graduated glassware used by creameries. Beginning with January, 1914, the purely executive part of these laws is handled by the Commissioner of Agriculture. It is still the duty of the Director of the Station to make the analytical examination of the samples collected by the Commissioner and to publish the results of the analyses. The cost of the inspections is borne by fees and by a State appropriation.

OFFICES AND LABORATORIES.

The offices, laboratories and poultry plant of the Maine Agricultural Experiment Station are at the University of Maine,

AROOSTOOK FARM.

Orono. Orono is the freight, express, post, telegraph and telephone address for the offices and laboratories.

By action of the Legislatures of 1913 and 1915 a farm was purchased in Aroostook County for scientific investigations in agriculture to be under "the general supervision, management, and control" of the Maine Agricultural Experiment Station. The farm is in the town of Presque Isle, about 2 miles south of the village, on the main road to Houlton. The Bangor and Aroostook railroad crosses the farm

The farm contains about 275 acres, about half of which is cleared. The eight room house provides an office, and home for the farm superintendent. A school house on a lot adjoining the farm was presented to the State by the town of Presque Isle and after being remodeled serves as a boarding house for the help. A greenhouse and a potato storage house have been erected at the farm by the U. S. Department of Agriculture for use in cooperative work on potato breeding. The large barn affords storage for hay and grain and has a large potato storage house in the basement.

HIGHMOOR FARM.

The State Legislature of 1909 purchased a farm upon which the Maine Agricultural Experiment Station was directed to "conduct scientific investigations in orcharding, corn and other farm crops." The farm is situated largely in the town of Monmouth. It is on the Farmington Branch of the Maine Central Railroad, 2 miles from Leeds Junction. A flag station, "Highmoor," is on the farm.

The farm contains 225 acres, about 200 of which are in orchards, fields, and pastures. There are in the neighborhood of 3,000 apple trees upon the place which have been set from 20 to 30 years. The house has 2 stories with a large wing, and contains about 15 rooms. It is well arranged for the Station offices and for the home of the farm superintendent. A substantially constructed building for apple packing was erected in 1912.

The removal of the crossbred herd from the University to Highmoor necessitated considerable change in the barns and the

PUBLICATIONS.

building of a new one 80 x 36 to accommodate the herd. This barn has a basement for manure, the cow stanchions above, and a loft for storage of hay.

The Station is organized so that the work of investigation is distinct from the work of inspection. The results of investigation are published in the bulletins of the Station and in scientific journals, both foreign and domestic. The bulletins for the year make up the annual report. The results of the work of inspection are printed in publications known as Official Inspections. These are paged independently of the bulletins and are bound in with the annual report as an appendix thereto. Miscellaneous publications consisting of newspaper notices of bulletins, newspaper bulletins and circulars which are not paged consecutively and for the most part are not included in the annual report are issued during the year.

BULLETINS ISSUED IN 1923.

No. 310. The Cause and permanence of Size Differences in Apple Trees. 8 pages, 1 page plate.
No. 311. Studies in Milk Secretion. XIV. The Effect of Age on the Milk Yields and Butter-fat Percentages of Guernsey Advanced Registry Cattle. 12 pages.
No. 312. Potato Spindle-tuber. 24 pages, 4 pages of plates.
No. 313. The Summer Food Plants of the Green Apple Aphid. 24 pages.
No. 314. Studies on Conformation in Relation to Milk Producing Capacity in Cattle. III. Conformation and Milk Yield in the Light of the Personal Equation of the Dairy Cattle Judge. 28 pages.

OFFICIAL INSPECTIONS ISSUED IN 1923.

No. 107. Foods and Drugs. 8 pages.
No. 108. Commercial Feeding Stuffs, 1922-1923. 20 pages.
No. 109. Commercial Fertilizers, 1923. 24 pages.
No. 110. Insecticides & Fungicides, 1923. 8 pages.

PUBLICATIONS FROM THE BIOLOGICAL LABORATORY IN 1923.

The Place of Stocks in the Propagation of Clonal Varieties of apples. By Karl Sax and John W. Gowen. Genetics, Vol. 8, pp. 458-465, 1923.

Bud and Root Selection in the Propagation of the Apple. By Karl Sax. Proceedings of the American Society of Horticultural Science, pp. 1-7, 1923.

Color factor in Bean Hybrids. By Karl Sax and Hugh C. McPhee. Journal of Heredity, Vol. 14, pp. 205-208, 1923.

The Association of Size Differences with Seed-Coat Pattern and Pigmentation in Phaseolus Vulgaris. By Karl Sax. Genetics, Vol. 8, pp. 301-321, 1923.

Permanence of Tree Performance in a Clonal Variety, and a Critique of the Theory of Bud Mutation. By Karl Sax and John W. Gowen. Genetics, Vol. 8, pp. 179-211, 1923.

The Relation Between Chromosome Number, Morphological Characters and Rust Resistance in Segregates of Partially Sterile Wheat Hybrids. By Karl Sax. Genetics, Vol. 8, pp. 301-321, 1923.

Productive and Unproductive Types of Apple Trees. By Karl Sax and John W. Gowen. Journal of Heredity, Vol. 12, pp. 291-300, 1921.

PUBLICATIONS FROM THE PLANT PATHOLOGICAL LABORATORY IN 1923.

A "Spindling-Tuber Disease" of Irish Potatoes. By Eugene S. Schultz and Donald Folsom. Science n.s. Vol. 57, No. 1466, p. 149, February 2, 1923.

Mutations of the Potato. Two Somewhat Unstable Leaf-form Sports of the Irish Potato. By Donald Folsom. Journal of Heredity, Vol. 14, No. 1, pp. 45-48. April, 1923.

Transmission, Variation, and Control of Certain Degeneration Diseases of Irish Potatoes. By E. S. Schultz and Donald Folsom. Journal of Agricultural Research, Vol. 25, No. 2, pp. 43-117. July 14, 1923.

STATION NOTES

COUNCIL AND STAFF CHANGES

Mr. Hugh B. Smith was appointed as Assistant Biologist July 1, 1923.

Miss Iva A. Merchant was appointed as Scientific Aid May 15, 1923.

Ila K. White resigned as clerk in the Station office on March 31, 1923 and Miss Margaret M. Honey was appointed to a similar position on April 1, 1923. Miss Emmeline D. Wilson was appointed as Laboratory Assistant in Biology on January 12, 1923.

Miss Viola Morris resigned as Laboratory Assistant in Plant Pathology June 30, 1923 and Miss Louise M. Baker was appointed to similar position November 1, 1923.